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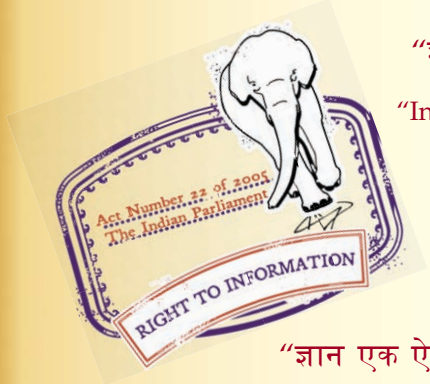

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IS : 11702 (Part 2) - 1986
(Reaffirmed 2005)

Indian Standard

MEASUREMENT OF AIRBORNE NOISE EMITTED BY PNEUMATIC TOOLS AND MACHINES

PART 2 METHOD FOR CHECKING COMPLIANCE WITH NOISE LIMITS

UDC 621·542 : 534·835·46 : 534·833·522 : 534·832-7

INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

February 1987

Gr 6

Indian Standard

MEASUREMENT OF AIRBORNE NOISE EMITTED BY PNEUMATIC TOOLS AND MACHINES

PART 2 METHOD FOR CHECKING COMPLIANCE WITH NOISE LIMITS

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Indian Standard

MEASUREMENT OF AIRBORNE NOISE EMITTED BY PNEUMATIC TOOLS AND MACHINES

PART 2 METHOD FOR CHECKING COMPLIANCE WITH NOISE LIMITS

0. FOREWORD

0.1 This Indian Standard (Part 2) was adopted by the Indian Standards Institution on 26 May 1986, after the draft finalized by the Acoustics Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 This standard specifies methods for determining and presenting the acoustic characteristics of pneumatic tools and machines.

0.3 The purpose of this standard is to provide data on acoustic performance of machinery for acoustic planning and for checking compliance with noise limits.

0.4 For acoustic planning, the determination of both A-weighted and octave band sound power levels are normally required, whereas for checking compliance with noise limits normally only the A-weighted sound power level is required.

0.5 The more comprehensive data obtained in Part 1 may be used not only for acoustic comparison of different types of machines and for prediction of disturbance in the near vicinity (in the case of a machine operating outdoors, for example, on a building site), but also as a contribution towards assessing the risk of hearing damage for people operating or working close to the machine.

0.6 This standard deals, firstly, with determination of surface sound pressure levels and, secondly, with the calculation of sound power levels. The measurements shall be made in a free field over a reflecting plane. An example of the recommended form of test report is also included.

0.7 This standard has been divided into two parts. Part 1 is an engineering method for determination of sound power levels, and gives information for acoustic planning. Part 2 is a method for checking compliance with noise limits, and is primarily used for type approvals in accordance with legal or contractual requirements. Both parts are complete in themselves and independent of each other.

0.8 The operating conditions in Part 1 are as far as possible conditions met in everyday use of the machinery which tend to give a relatively high degree of uncertainty. The operating conditions in this part are chosen so as to give the best possible repeatability of test results involving, if necessary, the isolation of machine noise and suppression of the tool and process noise.

0.9 Section 1 of this part gives a general specification of measurement methods valid for all types of machines covered. Section two lays down special operating conditions for the various types of machines. If, in future, new machines are to be added, this can conveniently be done by adding further sections, thus maintaining the format of this part.

0.10 While preparing this standard, assistance has been derived from ISO/DIS 3481|2.2 'Acoustics — Measurement of airborne noise emitted by pneumatic tools and machines, Part 2 Method for checking compliance with noise limits' issued by International Organization for Standardization (ISO).

0.11 In reporting the result of a test made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

SECTION 1 GENERAL SPECIFICATION

1. SCOPE

1.1 This standard (Part 2) specifies a method for measuring the airborne noise emitted by pneumatic tools and machines and stipulates precise instructions for conducting the tests and reporting the results, for the purpose of checking noise limits.

1.2 This standard covers measurements in a free field over a reflecting plane. Only the A-weighted surface sound pressure level is measured and the sound power is determined. It applies, for example, to rock-drills (sinkers), paving-breakers, pickhammers, plug-hole-drills, picks and spades.

*Rules for rounding off numerical values (*revised*).

1.3 Devices emitting isolated sound bursts, for example, low frequency pile-drivers, or series of sound pulses with a repetition frequency lower than 10 Hz are not covered by this part.

2. TERMINOLOGY

2.1 For the purpose of this standard, the terms and definitions given in IS : 1885 (Part 3)* shall apply.

3. REFERENCE PRESSURE AND REFERENCE POWER

3.1 In this standard the reference pressure of 20 μPa is used for the expression of sound pressure level and the reference power of 1 pW is used for the expression of sound power level.

4. INSTRUMENTATION

4.1 General

4.1.1 The instrumentation shall be designed to permit the determination of the value of the A-weighted sound pressure level averaged over time. Tolerances as regards the several components comprising the instrumentation system shall not exceed the tolerances given in the relevant clauses of IS : 9779 - 1981†, type 1 or better.

NOTE 1 — An example of an appropriate instrument for these measurements is a sound level meter that fulfils at least the requirements for a type 1 instrument, conforming with IS : 9779-1981† with a 'slow' meter characteristic. In addition, for establishing the presence of impulsive noise, the 'impulsive' meter characteristic, conforming with IS : 9779 - 1981† shall be used.

NOTE 2 — Another example of an appropriate instrumentation system is an integrator which carries out an analogue or digital integration of the squared signal over a given time interval.

4.2 Microphone and Associated Cable

4.2.1 So as to minimize the influence of the observer on the measurements, a cable should preferably be used between the microphone and the sound level meter. The observer shall not stand between the microphone and the source the sound power level which is being determined. The microphone shall comply with the specifications given in IS : 9779-1981†, type 1 or better.

4.3 Frequency Response of the Instrumentation System

4.3.1 The frequency response of the instrumentation system for the angle of incidence specified by the manufacturer shall be within the tolerances given in IS : 9779-1981†.

*Electrotechnical vocabulary : Part 3 Acoustics.
†Specification for sound level meters.

4.4 Calibration

4.4.1 At least before each series of measurements an acoustic calibrator with an accuracy of $\pm 0{\cdot}5$ dB shall be applied to the microphone to calibrate the entire instrumentation system, including cable, if used, at one or more frequencies. One calibration frequency should be in the range from 250 to 1 000 Hz. The calibrator shall be checked annually to verify that its output has not changed.

5. OPERATING AND LOADING

5.1 The machine shall be operating in stable condition as for normal continuous service.

5.2 The machine shall be operated at an effective working pressure of 6 bar or at rated pressure, if this is considered more normal, and rated energy supply. During testing, air pressure shall be measured at the coupling which is closest to the machine while it is in operation. The machine shall operate normally; restriction of the exhaust by freezing shall be avoided. The type, quality and quantity of lubricant shall be as recommended by the manufacturer.

NOTE — The pressure may be checked by means of a dial pressure gauge, but, in view of the pulsation of the machine, it is preferable to use an arrangement consisting of an air receiver with a capacity of 50 to 100 l, supplied by a conventional hose, 20 m in length with a diameter of 19 mm. The machine will be supplied from this receiver through a hose, with a diameter between 25 and 30 mm diameter, and 4·5 mm in length connected to the coupling. The receiver shall be as far away from the machine as possible. The pressure inside the receiver shall be measured through a connection.

The pressure may be adjusted either through the outlet valve on the compressor or by a calibrated pressure regulator.

A schematic diagram illustrating a typical device for a paving-breaker is given in Fig. 1.

For operating and loading specifications, the relevant section should be referred to.

6. REFERENCE AND MEASUREMENT SURFACES

6.1 Reference Parallelopiped

6.1.1 So as make the location of the microphone positions, more straightforward, the smallest possible imaginary rectangular parallelopiped (length l_1, width l_2, height l_3), just enclosing the source and terminating on the reflecting plane, is used for reference purposes. When defining the parallelopiped, small elements protruding from the source, which are unlikely to be major radiators of sound energy, may be disregarded.

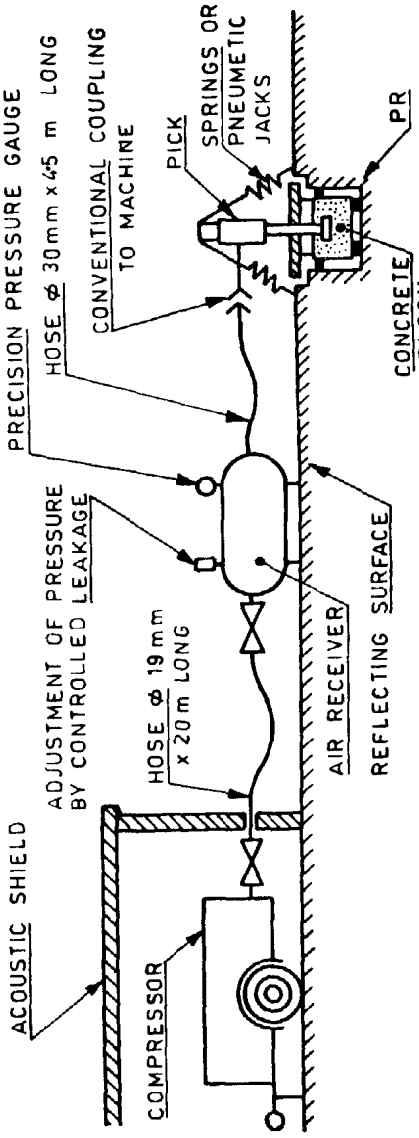


FIG. 1 EXAMPLE OF DEVICE FOR SUPPLYING COMPRESSED AIR

6.2 Measurement Surface

6.2.1 The measurement surface is a hypothetical hemisphere with its geometric centre at the point at which the geometric centre of the reference parallelopiped is projected into the reflecting plane.

6.2.2 The radius of the hemispherical measurement surface shall be 2 m or 4 m depending on the relevant section.

7. NOISE MEASUREMENT

7.1 Test Environment

7.1.1 A suitable test area shall be a hard reflecting surface of such diameter that all microphone positions are within its perimeter. A qualification procedure for determining the adequacy of the acoustical environment and methods for determining the environmental correction factor, if necessary, are given in Indian Standard measurement of airborne noise emitted by construction equipment intended for outdoor use — Method for checking compliance with noise limits (*under preparation*). A surface of concrete or impervious asphalt may, for example, be satisfactory.

7.1.2 The presence of large objects such as buildings and machines within a radius of 10 m from the machine being tested shall be avoided. Measurements may be carried out indoors, if a suitable test room is available.

NOTE — Care shall also be taken to ensure that gusts of wind do not distort the results of the measurements and that no microphone is placed in the exhaust air zone during the measurement. A microphone wind-screen shall be used. If necessary, in this case, a specified calibration correction may be required. Wind speed should not exceed 8 m/s.

7.2 Background Noise

7.2.1 The sound pressure level of the background noise with the machine being tested but not running shall be determined at the microphone positions to be used when carrying out the tests. The period of measurement shall be long in relation to any fluctuation in the background sound pressure level observed so that a correct average reading can be obtained with the 'slow' response setting of the sound level meter.

7.2.2 The readings at each position, with the machine running, should preferably exceed the background sound pressure level by at least 10 dB. If the difference is less, corrections shall be applied as shown in Table 1.

7.2.3 If the difference between the measured sound pressure level and the background sound pressure level is less than 6 dB, a valid result cannot be obtained.

TABLE 1 CORRECTIONS TO BE APPLIED

(*Clauses* 7.2.2 *and* 8.1.2)

Difference Between Sound Pressure Level Measured with Sound Source Operating and Background Sound Pressure Level Alone	Correction to be Subtracted from Sound Pressure Level Measured with Sound Source Operating to Obtain Sound Pressure Level due to Sound Source Alone
dB	dB
6 to 8	1·0
9 to 10	0·5
Greater than 10	0

7.3 Measurements

7.3.1 *General*

7.3.1.1 Observers and measuring instruments shall be at least 1 m behind the microphone. Care shall be taken to ensure that operating personnel do not come between or in line with the machine and the microphone while readings are being taken so as not to impair the validity of the measurements.

7.3.2 *Readings to be Recorded*

7.3.2.1 The A-weighted sound pressure levels shall be recorded at each microphone position as specified in **7.3.3**, with the machine being tested running as laid down in **5**. The sound level meter shall be used on the 'slow' response setting.

7.3.3 *Microphone Positions*

7.3.3.1 The microphone shall be located on the measurement surface in accordance with the specifications laid down in the relevant section.

7.3.4 *Measurement Technique*

7.3.4.1 With the microphone in each of the positions given in the relevant section, the sound pressure levels shall be recorded as specified in **7.3.2**.

7.3.4.2 The period of measurement shall be long in relation to any fluctuation in sound pressure level observed so that a visual average reading can be obtained with the 'slow' response setting of the meter.

7.3.4.3 The microphone shall be held in the position of grazing incidence or perpendicular incidence as recommended by the manufacturer.

NOTE — If the noise from the machine being tested contains strong audible discrete frequency components, errors in the measurement results may occur. Where the discrete-frequency components are of high frequency, the errors can be reduced by slowly raising and lowering the microphone by approximately $\pm 0{\cdot}3$ m from each nominal microphone position. During the movement, care shall be taken to avoid the generation of noise, either mechanical or aerodynamic in origin, which could influence the measurements. If the moving microphone technique is used, this shall be reported.

8. CORRECTIONS AND CALCULATIONS

8.1 Application of Corrections

8.1.1 Instrumentation calibration corrections and wind-screen corrections shall be applied, as appropriate.

8.1.2 Readings shall be corrected for the influence of background noise in accordance with Table 1.

8.2 Calculation of the Surface Sound Pressure Level

8.2.1 If the spread between the readings for one set of microphone positions does not exceed 5 dB, the surface sound pressure level can be obtained by arithmetically averaging the readings and subtracting the environmental correction K (*see* below).

8.2.2 If the spread exceeds 5 dB, the A-weighted surface sound pressure level L_p in decibels, is calculated using the following formula:

$$L_p = 10 \log \left[\frac{1}{N} \left(\text{antilog} \frac{L_1}{10} + \text{antilog} + \frac{L_2}{10} + \ldots + \text{antilog} \frac{L_n}{10} \right) \right] - K$$

where

L_1 is the sound pressure level, at microphone position No. 1, in decibels, corrected in accordance with **8.1**;

L_n is the sound pressure level, at microphone position No. n, in decibels, corrected in accordance with **8.1**;

N is the number of microphone positions at a given distance; and

K is the environmental correction, in decibels, as determined by one of the procedures specified in Indian Standard measurement of airborne noise emitted by construction equipment intended for outdoor use — Method for checking compliance with noise limits (*under preparation*) for test environments meeting the requirements of **7.1**, $K = 0$.

9. CALCULATION OF THE SOUND POWER LEVEL

9.1 Area of the Measurement Surface

9.1.1 For the purposes of calculating sound power level, the area S of the measurement surface, in square metres, shall be calculated from the formula

$$S = 2\pi r^2$$

where r is the radius of the hemispherical measurement surface, in metres.

9.2 Calculation of A-Weighted Sound Power Level

9.2.1 The weighted sound power level, L_w, in decibels, of the machine being tested is given by the formula

$$L_w = L_p + 10 \log\left(\frac{S}{S_0}\right)$$

where

L_p is the surface sound pressure level, in decibels of the machine being tested, calculated in accordance with **8.2**;

S is the area of the measurement surface, in square metres, calculated in accordance with **9.1**; and

$S_0 = 1\ m^2$.

The logarithmic relation $10 \log \left(\frac{S}{S_0}\right)$ is 20 dB for a hemisphere radius of 4 m and 14 dB for a hemisphere radius of 2 m.

10. TEST REPORT

10.1 The test report shall include at least the following information :

a) reference to this part;

b) a description of the machine being tested (including make, model and serial number);

c) the operating conditions (including ambient temperature, wind speed and air pressure at the machine) and nature of the energy-absorbing device;

d) a sketch showing the test layout, pinpointing the microphone positions and indicating the direction and distance to large objects within the test area;

e) the make, model and serial number of the acoustic instrumentation used, including any device used for protecting the microphone against effect of wind, and calibration method;

f) the A-weighted background sound pressure level, in decibels, at the microphone positions used for the test; the correction shall be stated;

g) the sound pressure level at each microphone position, reported in the table in the test report (after the correction for background noise and wind-screening have been made);

h) the environmental correction factor, to be stated in the table in the test report;

j) the surface sound pressure level, corrected by the environmental correction factor;

k) graphs giving A-weighted surface sound pressure level; and

m) the directivity index in accordance with the specifications of Appendix A.

For the purposes of stating sound power, the following additional information shall be given:

a) the area of the measurement surface, in square metres; and

b) the A-weighted sound power level.

The recommended format for the test report is shown in Appendix B.

SECTION 2 SPECIAL TEST CONDITIONS FOR PAVING-BREAKERS, PICKHAMMERS, ETC

11. GENERAL

11.1 For the purposes of testing the noise emission from paving-breakers, pickhammers, plug-hole-drills and similar tools used on building sites, the special test conditions given in this section are applicable. The general specifications laid down in **1** to **10** shall be valid for the test.

12. LOADING OF MACHINE

12.1 During the test the machine shall be operated in the following way:

a) In a vertical position on the device consisting of a concrete block in which a tool is embedded (*see* **13**). The device shall be placed in a concrete pit (*see* **14**).

b) Unattended by an operator and firmly held down on the tool shank described below by means of a flexible device preventing the machine from bouncing while operating, that is, giving the same operating conditions as when the tool is embedded in the material to be broken up, before it fractures. The flexible device may take the form of calibrated springs or pneumatic jacks.

13. CONCRETE BLOCK AND TOOL

13.1 General

13.1.1 The machine shall be run, as described in **12**, on the tool which is embedded in a cube-shaped concrete block, placed in a concrete pit, below the surface of the ground. The tool shank shall be tested for correct type and dimensions for the machine.

13.2 Block Characteristics

13.2.1 The block shall be in the shape of a regular cube with 0·6 m sides, it shall be made of reinforced concrete and thoroughly vibrated in layers up to 0·2 m to avoid excessive sedimentation.

13.3 Composition of Concrete

13.3.1 The concrete for the block shall have the following proportions:

a) 50 kg pure Portland cement, class 400 or equivalent;

b) 65 l of ungraded, non calcareous sand with a grain size of 0·5 to 5 mm; and

c) 115 l of calcareous, alluvial gravel with a grain size of 5 to 25 mm.

The cube shall be reinforced by 8 mm steel rods without ties, each rod being independent of the others.

The design concept of the block is illustrated in Fig. 2.

13.4 Tool

13.4.1 The tool shall be sealed into the concrete and shall consist of a rammer of not less than 178 mm and not more than 220 mm in diameter and a tool chuck component identical to that normally used with the pick or concrete-breaker to be tested. The tool shall comply with the relevant standard and shall be long enough to enable the practical test to be carried out.

13.4.2 Suitable treatment shall be carried out to integrate the two components. The tool shall be fixed in the block so that the bottom of the rammer is 0·30 m from the upper face of the block (*see* Fig. 2).

13.4.3 The block shall reamin mechanically sound, particularly at the point where the supporting tool and the concrete meet before and after each test it should be ensured that the tool sealed in the concrete block is integrated with it.

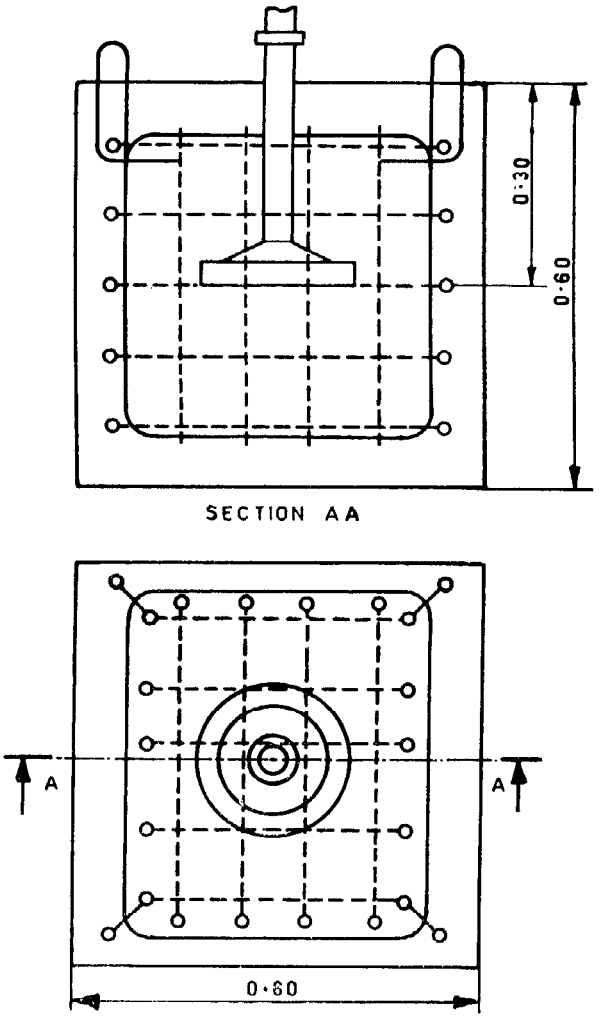
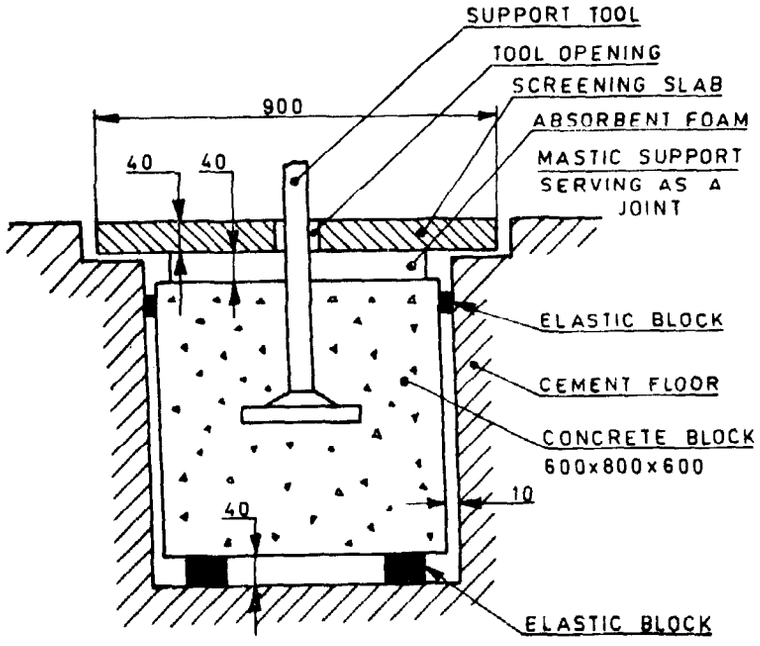


FIG. 2 CONCRETE BLOCK AND TOOL

13.5 Test Site

13.5.1 The concrete block with the tool shall be set into a pit which is cemented throughout. The block shall be covered by a screening slab weighing at least 100 kg/m², as indicated in Fig. 3. The upper surface of the screening slab is flush with the ground. The block shall be insulated against the bottom and sides of the pit by means of elastic blocks. They should have a cut-off frequency which shall be not more than half the blow frequency of the paving-breaker or hammer to be tested.



All dimensions in millimetres.

FIG. 3 TEST SITE

13.5.2 The opening in the screening slab through which the tool shank component passes shall be as small as possible and be sealed by a flexible sound proof joint.

13.6 Measurement Surface and Microphone Positions

13.6.1 The measurement surface in accordance with **6.2** shall be chosen according to Table 2.

TABLE 2 CHOICE OF MEASUREMENT SURFACE AND MICROPHONE POSITIONS

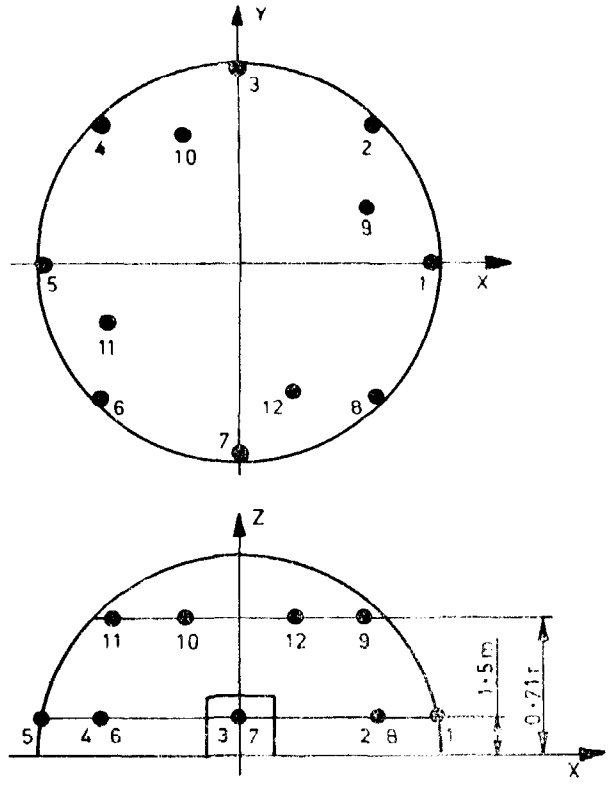
(*Clause* 13.6)

WEIGHT OF THE PAVING-BREAKER OR HAMMER AS NORMALLY USED AND EXCLUSIVE OF TOOL	HEMISPHERE RADIUS	HEIGHT ABOVE GROUND FOR MEASUREMENT POSITIONS	
		m	
kg	m	1 to 8	9 to 12
< 10	2	0·75	1·40
⩾ 10	4	1·50	2·80

13.6.2 In Fig. 4, measurement positions 1, 3, 5, 7, 9, 10, 11 and 12 are the key measurement points which should always be used. If it is deemed necessary to introduce more measurement positions, they should conform with measurement positions 2, 4, 6 and 8.

In no circumstances are more than 12 measurement positions necessary.

13.6.3 The exhaust shall be directed to fall between one of the following pairs of microphone positions, between 2 and 3, 4 and 5, 6 and 7 or 8 and 1.



r = Radius of hemisphere

FIG. 4 MICROPHONE ARRAY FOR MEASUREMENT OF NOISE FROM PAVIN-BREAKERS

APPENDIX A

(*Clause* 10.1)

DETERMINATION OF DIRECTIVITY INDEX

A-1. The directivity index, *DI*, of a source operating in a free field above a reflecting plane is defined as the difference between the highest value of the A-weighted sound pressure level measured at one of the microphone positions and the energy-averaged value of the A-weighted sound pressure levels at all of the microphone positions:

$$DI = L_{p1} - \bar{L}_p$$

where

L_{p1} is the highest value of the A-weighted sound pressure level, in decibels, at the microphone positions;

$\bar{L}_p$ is the energy-averaged mean A-weighted sound pressure level, in decibels, at all microphone positions.

NOTE 1 — This formula is different from that of Indian Standard measurement of airbrone noise emitted by constructional equipment intended for outdoor use — Method for checking compliance with noise limits (*under preparation*), which is given for spherical radiation.

NOTE 2 — For some purposes it may be advantageous to calculate the directivity index for a particular plane, for example, the horizontal plane. For these purposes the directivity index is defined as the difference between the highest value of the A-weighted sound pressure level measured at one of the microphone positions in the plane and the energy-averaged value of the A-weighted sound pressure levels at all the microphone positions in the plane:

$$DI = L_{p1} - \bar{L}_p$$

where

L_{p1} is the highest value of the A-weighted sound pressure level, in decibels, at microphone positions in one plane;

$\bar{L}_p$ is the energy-averaged mean A-weighted sound pressure level, in decibels, at all microphone positions in the same plane.

APPENDIX B

(*Clause* 10.1)

FORMAT FOR HAND-HELD TOOL REPORT

Report on Tool Noise Test

The following test has been made in accordance with this standard.

1. Description of Tool

Manufacturer: ....

Model: .... Serial No. .....

Rated speed and capacity: .....

Description: .....

2. Operating Conditions

2.1 On load—Rotational/blow frequency, r/min: .....

Air pressure supplied, bar: ..... Air flow, l/s: .....

2.2 Running free—Speed, rev/min: .....

2.3 Nature of energy-absorbing device: .....

3. Test Conditions

Barometric pressure, bar: ..... Ambient temperature, °C: .....

Wind speed, m/s: .....

Reflecting plane, composition and dimensions, m: .....

Remarks: .....

4. Instrumentation

Microphone: ..... Serial No. :.....

Sound level meter: ..... Serial No. :.....

Octave band analyser: ..... Serial No. :.....

Calibrator: ..... Serial No. :.....

Other, for example wind-screen or recorder: ..... Serial No. :.....

5. Test Layout

Area of the measurement surface, m^2: .....

Sketch showing microphone positions, orientation of machine, direction of exhaust, direction and distance to large objects near machine being tested.

Height above reflecting plane: .....

Background noise measured at microphone position No.: .....

The test results are given in the table on the following page.

Reported by: ..... Date: .....

Approved by: ..... Date: .....

REPORT ON TOOL NOISE TEST

Sound Pressure and Sound Power Levels

	Test conditions	Microphone position No.	A-weighted sound pressure level
On-load conditions	Microphone readings, corrected for background noise and wind-screen if any	1	
		2	
		3	
		4	
		5	
		6	
		7	
		8	
		9	
		10	
		11	
		12	
	Average		
	Environmental correction K		
	Mean surface sound pressure level corrected for environment		
	Measurement surface, expressed as 10 lg (S/S_0)		
	Sound power level		
Running free	Microphone readings corrected for background noise and wind-screen, if any	1	
		2	
		3	
		4	
		5	
		6	
		7	
		8	
		9	
		10	
		11	
		12	
	Average		
	Environmental correction K		
	Mean surface sound pressure level corrected for environment		
	Measurement surface, as 10 lg (S/S_0)		
	Sound power level		

NOTE — Readings that need correction for background noise shall be shown in parentheses.